# Pollution Prevention
# for
# Reciprocating Internal Combustion Engines

**September 3, 1998**

The Coordinating Committee (CC) formed a Pollution Prevention (P2) Subgroup that developed recommendations for pollution prevention. The CC requested that individual source Work Groups review and consider the applicability of these recommendations. The Reciprocating Internal Combustion Engine (RICE) Work Group (WG) has reviewed these recommendations with regards to stationary reciprocating internal combustion engines. The recommendations of the RICE (WG) on the following P2 Subgroup recommendations are provided below:

- Good Combustion Practices
- Operator Training
- P2 Metrics
- Fuel Constituent Standards

The P2 Subgroup recommendations on P2 MACT Options (Alternative Compliance) P2 Planning and Fuel/Waste Deminimus Levels have not been reviewed by the RICE WG due to a lack of time to fully consider these recommendations. The P2 Subgroup recommendations on Waste Accounting and Record keeping and Work Practice Standards have not been reviewed by the RICE Work Group because those recommendations, made only for ICCR sources burning solid waste and waste mixtures subject to contamination, do not apply to stationary RICE.

## Good Combustion Practices

Most of the P2 Subgroup recommendations with regards to Good Combustion Practices (GCPs) were identified for open combustion systems, such as boilers. The P2 Subgroup recommended that all Source Work Groups review the applicability of operator practices, maintenance knowledge, and maintenance practices.

IC engines are used in a variety of stationary applications such as driving pumps, compressors, electric power generators, and mechanical devices. Good engine performance for these applications is necessary for both cost-effective operations and, in some cases, for compliance with local and state regulatory requirements for criteria pollutant emissions. In general, good engine performance is sustained by proper engine operation, routine engine inspection, and engine performance analysis, and, as necessary preventative maintenance. Most existing practices have been developed as a result of economic incentives to improve fuel efficiency and avoid costs associated with engine failure or as a result of air emission limitations for criteria pollutants. The RICE Work Group reviewed possible good combustion practices, as it relates to HAP emissions, as a part of the MACT floor review for existing RICE. Based on that review, the RICE Work Group concluded that practices that maintain good engine performance may lead to more complete combustion, and therefore, may decrease the likelihood of increased HAP emissions that may be associated with incomplete combustion or engine failure. The effectiveness of existing practices for fuel efficiency or NOx emission reduction is well documented. However, the RICE Work Group has not identified any data to link improved maintenance, inspection, and operating practices to reduced HAP emissions. In addition, specific recommendations for maintenance and operating practices are engine-specific, site-specific, or both. Therefore, based on a review of all information available, the RICE Work Group concluded that there are no specific practices at this time that is appropriate for the MACT floor for existing RICE.

A description of existing operating and maintenance practices is provided below.

All engine manufacturers provide their customers with preventative maintenance recommendations which specify a logical sequence of inspections and repair actions that are necessary to ensure good engine performance and to prevent failures from occurring. Some examples of engine items related to engine performance that should be inspected, serviced, and/or replaced routinely are engine air cleaners, turbochargers, spark plugs, valve lash, ignition systems, ignition coils and wiring and aftercooler cores. Manufacturers' recommendations for specific inspection/maintenance schedules may differ depending on the design and size of engines and whether the engine is a compression-ignition (CI) or a spark-ignited(SI) engine. Engine manufacturers provide Maintenance Manuals for their products which describe in considerable detail what to maintain and how to perform the maintenance. Engine owners may train on-site personnel to maintain an engine, or, in some cases, contract with the engine dealer to provide a trained serviceman to perform the recommended inspection and maintenance.

Some engine users develop site-specific programs of engine inspection and analyses to evaluate engine performance. These programs generally have been developed as a result of economic incentives and are implemented in lieu of the inspection/maintenance schedules recommended by the engine manufacturer. Typical engine parameters that may be monitored in these site-specific programs include operating temperatures, pressures, and fuel consumption. These engine users rely on their extensive experience with specific engines to develop these site-specific programs and to identify when changes in the monitored parameters indicate the need for engine maintenance.

One of the most extensive maintenance procedures for stationary IC engines is overhaul. The overhaul period of an engine is defined as the interval after which the major wear items in the engine should be replaced. Many of the items that are replaced or rebuilt after this interval are load sensitive and total fuel consumed may be used to determine the point of overhaul rather than clock hours. Manufacturers provide information on how to adjust clock hours to account for fuel used. Therefore, hours to overhaul are application-specific and are based on a user's knowledge, experience, and records of operation.

Maintenance records are important to the user, the manufacturer, and the regulator. Accurate records can be used to determine operating costs, establish maintenance schedules and for a variety of business decisions. Accurate records can also be used as proof of maintenance or repair for warranty claims. Accurate maintenance records may also be a requirement for some permits in order to verify agreed upon emissions inspections are conducted at specific intervals which are generally those recommended by the manufacturer.

Good engine performance is the result of good inspection/maintenance programs. As discussed, procedures provided by engine manufacturers and in some cases, site-specific programs, are in place for the proper maintenance of stationary IC engines. With the wide variety of engines, manufacturers, and users, the WG recommends that any regulatory language covering this topic should be general and limited to the need to have inspection/maintenance procedures in place and appropriate records to verify that such procedures are followed.

## Operator Training

"Operator" has been defined by the Pollution Prevention Subgroup as an individual whose work duties include the operation, evaluation, and/or adjustment of the combustion system, i.e., internal combustion engine. The P2 Subgroup recommended that Source Work Groups consider the following general requirements for operator training:

- Operators of an affected source shall be trained and qualified.

- Training programs and qualification exams shall include the environmental concerns, including air pollutant emissions, basic combustion principles, including products of combustion, operating procedures, combustion controls and adjustments to minimize emissions, operation of air pollution control equipment, monitoring of emissions, operating parameters, and/or proper functioning of the air pollution control measures, routine inspection, actions to prevent and correct malfunctions, applicable regulatory and permit requirements, energy management and other pollution prevention measures, as applicable. The P2 Subgroup recommended that EPA designate model training/qualification programs and that States approve training/qualification programs that are substantially equivalent to the model programs.

- Training program materials and documentation of qualification shall be maintained and available for inspection when requested.

In response to the request of the Coordinating Committee, the RICE Work Group has evaluated whether operator training should be included as a requirement for the RICE MACT standard, issued under the authority of Section 112. [[Note: Operator training is required for ICCR sources that are covered by Section 129 standards. The RICE Work Group does not anticipate that any RICE will be covered by Section 129 standards.] In this evaluation, the RICE Work Group has considered two aspects of operator training 1) whether operator training for RICE could in fact result in reduced HAP emissions and 2) whether an operator training requirement would be viable for MACT.

## Whether Operator Training for RICE Could in Fact Result in Reduced HAP Emissions

Engine operation for stationary RICE differs depending on the type of engine, the engines use, the size of the engine, the level of automation and age of the unit. Engine operation for CI engines is very different from the operation requirements for SI engines.

CI engines are designed and manufactured to produce a certain amount of power at a specific engine speed. This power is achieved by the size of the engine, number of cylinders, and the proper selection of components such as fuel system, turbochargers, aftercoolers, and piston compression ratios. This design/selection process results in a matched set of components that determines the combustion process and results in an essentially adjustment-free engine that is ready to run when received by the customer. Procedures for starting and stopping the engine are covered in an Operation Manual, as are maintenance requirements previously described in this paper. A CI engine does not require an operator to evaluate and adjust the combustion system since the combustion process was determined and set by the manufacturer. Exhaust emissions resulting from the combustion process were also predetermined by the manufacturer and in accordance with the purchasers specifications. In fact, many CI engines operate unattended and may be started and stopped by remote control. The engines are equipped with sensors to detect high coolant temperature, low oil pressure, and excessive engine speed in the event of a malfunction. When sensors are tripped, the engine load will be reduced or the engine will be shut down.

SI engines are also set in the factory, but user installations may require site-specific adjustments depending on the type of fuel used and its heating value. The increased number of variables associated with SI engines requires more frequent attention from an operator. Periodic checks of the oxygen content in the exhaust are required to assure continued proper engine operation. Manufacturers provide Operating Manuals that describe procedures for measuring the oxygen content of the exhaust gas and adjusting spark timing and air-to-fuel- ratio to achieve the correct oxygen levels for proper engine performance.

With RICE engine performance and exhaust emissions predetermined by the manufacturer, there is little opportunity for an operator to adjust the combustion system thus minimizing training requirements. However, operators and/or servicemen do routinely conduct engine maintenance. For proper engine operation, it is important that maintenance personnel are trained to conduct proper engine maintenance and overhaul procedures so that engines continue to perform as intended. Training for these activities is available and in widespread use.

While the WG is aware that operator training for external combustion devices may demonstrate a quantifiable reduction in emissions, the RICE Work Group has not identified any information that establishes a correlation between operator training and reduced HAP emissions from internal combustion engines.

## Whether an Operator Training Requirement Would be Viable for RICE MACT

In assessing the possibility of using operator training as a requirement in the RICE MACT, members of the WG have identified significant practical difficulties that would be encountered in attempting to implement a training and certification requirement as a part of the RICE MACT. These include:

- The population of existing RICE is highly heterogeneous. Work Group members believe it would be difficult to develop a generic training program to cover all the engines in the existing population of RICE. The WG believes, that to be effective, a training program would need to be developed on a site-specific basis

- There are no known existing certification programs that target existing RICE generally. Although some manufacturers have limited training programs that focus on maintenance, there is no standard training or certification for existing RICE. This is due largely to the diversity of the engine population.

- The topics included in the P2 Subgroup's recommendations for training cover issues that extend much beyond the issues that are specific to RICE.

- Many installations of RICE may not have an operator, as defined by the P2 Subgroup. Some installations may consist of a single engine that is operated without supervision and maintained by trained service personnel from the engine dealer. For installations involving a number of engines that may operate continuously, there will be personnel in attendance to monitor the engine's operation and follow the maintenance plans developed for the specific engines and their type of operation and conditions.

- Current personnel do not have experience or training related to the topics recommended, other than operation and maintenance of the RICE.

- A training program that included the topics recommended by the P2 Subgroup would be prohibitively expensive.

Based on the fact that there is no evidence that there are quantifiable HAP emissions reduction as a result of operator training for internal combustion engines and based on the impracticality of implementing a training program for existing RICE, the Work Group recommends, based on the information available at this time, that no mandatory training requirements be considered for the Section 112 RICE MACT.

## Pollution Prevention Metrics

The P2 Subgroup recommended that Source Work Groups review the following metrics to determine whether the metrics may encourage pollution prevention when expressed alone as a MACT limit, when used as an equivalent limit in combination with a traditional limit, or an alternative compliance limit:

- Mass emissions/time
- Mass emissions/energy output
- Mass emissions/heat input
- Mass emissions/fuel or waste input
- Mass emissions/Unit of production
- Mass emissions/volume

The mass emissions from a RICE can be expressed, with proper measurements, in any of the above metrics. However, the emissions produced are a function of engine/controls design, proper maintenance, and operating conditions. Engines are designed to meet customer specified power and emission requirements which are fixed at the time of manufacture. Once the engine is placed in service, the mass emissions are determined by the demands on the engine. The load requirements may vary as well as the operating time.

The RICE Work Group concluded that the metrics identified above cannot be used as a tool to encourage pollution prevention from an engine. Engines are always part of a process which must be considered in total for pollution prevention.

## Fuel Constituent Standards

The P2 Subgroup recommended that Source Work Groups review the applicability of fuel constituent standards. Fuel switching or fuel treatment was suggested as a means for pollution prevention. For IC engines, the two primary fuels are diesel (liquid fuel) and natural gas. IC engines are designed to use a specific fuel so there can rarely be any switching between fuels for a given engine.

Stationary IC engines using commercially available diesel fuel have little or no opportunity to modify diesel fuel standards for several reasons. Diesel fuel standards are determined by the mobile on highway engine regulations. Due to the shear volume of fuel consumed by this source, the petroleum refiners want to produce one type of fuel for all engine applications to avoid the need to have duplicate storage facilities and distribution systems. Actually, stationary engines benefit from this consolidation of fuels in that regulatory action for improvements in diesel fuel for on highway engines will benefit stationary engines.

Natural gas for SI engines is a mixture of hydrocarbon and non-hydrocarbon gases found in geologic formations beneath the earth's surface. SI engines can operate on raw field gas, propane or on pipeline quality gas which is used primarily for home heating. Both commercial propane and pipeline natural gas constituents are regulated.